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Assessment of resource recovery within LCA

Innovative assessment of resource potentials in waste

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Introduction

Environmental Life Cycle Assessment (LCA) studies of Waste Management Systems (WMS) have until now almost entirely been applied using Gate-to-Grave boundaries (zero-burden approach).[1] This has several drawbacks:

- As the waste is "for free", it removes responsibility for optimal utilization of the input waste
- Modern WMSs becomes net saving systems without a possibility to compare to a baseline resource potential.

The purpose of this study is to investigate possibilities of **including upstream raw material production as "Resource Potential" in LCA of Waste Management Systems**

This can contribute to:

- Emphasize on recovery efficiency and effectiveness by comparing savings and recovery cost with the resource potential
- Performance comparison between different systems as well as for waste prevention modeling.

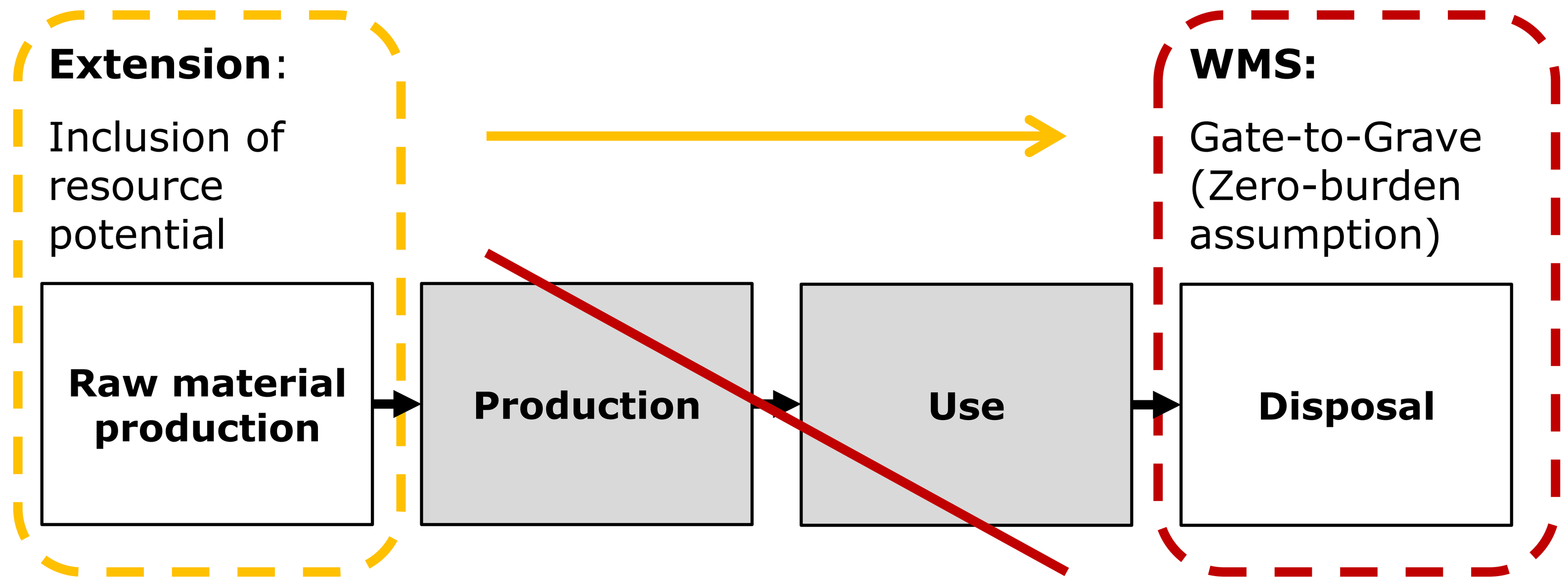

Figure 1: Inclusion of Raw material production as extension to state-of-the-art Gate-to-Grave LCA of WMS

Method

A LCA case study of aluminum recovery from bottom ash[2] is extended with virgin aluminum production corresponding to the amount present in the bottom ash.

- Functional Unit: 5,000 tonnes of bottom ash from incineration
- Geographical and temporal scope: Bottom ash management in Denmark, 2013
- Time horizon: 100 years
- Impact assessment: IPCC 2007, Climate change, GWP 100a

Two systems each with & without considering the Resource Potential, only difference is the aluminum content:

S1: 1.50 % Aluminum content in bottom ash
S2: 0.75 % Aluminum content in bottom ash

Recovery performance indicators are calculated as:

$$Resource\ effectiveness = \frac{Savings}{Resource\ Potential}, \qquad Resource\ efficiency = \frac{Savings - Recovery\ cost}{Resource\ Potential}$$

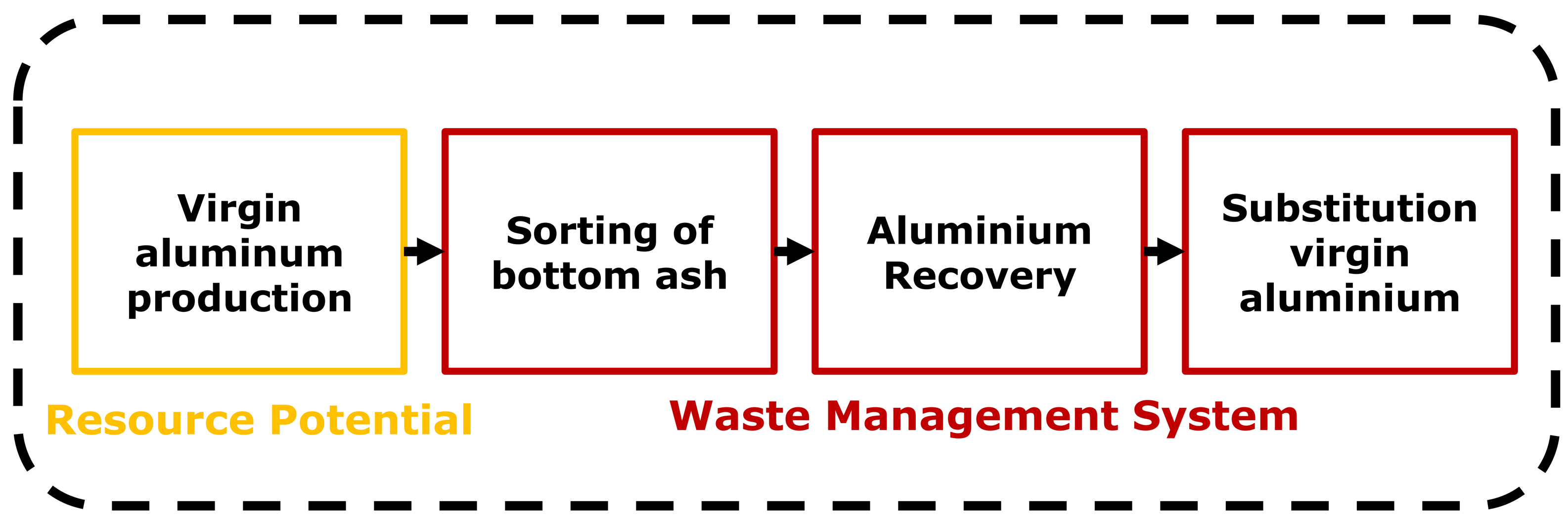

Figure 2: Conceptual model of the extended WMS as used for modeling Al recovery from bottom ash from incinerated household waste.

Results & Discussion

The **goal of resource recovery** is to **optimize savings over costs** given the available input material. Identifying the best combination of technologies in a system can be facilitated by assessing the effectiveness and efficiency of the recovery as done in the following.

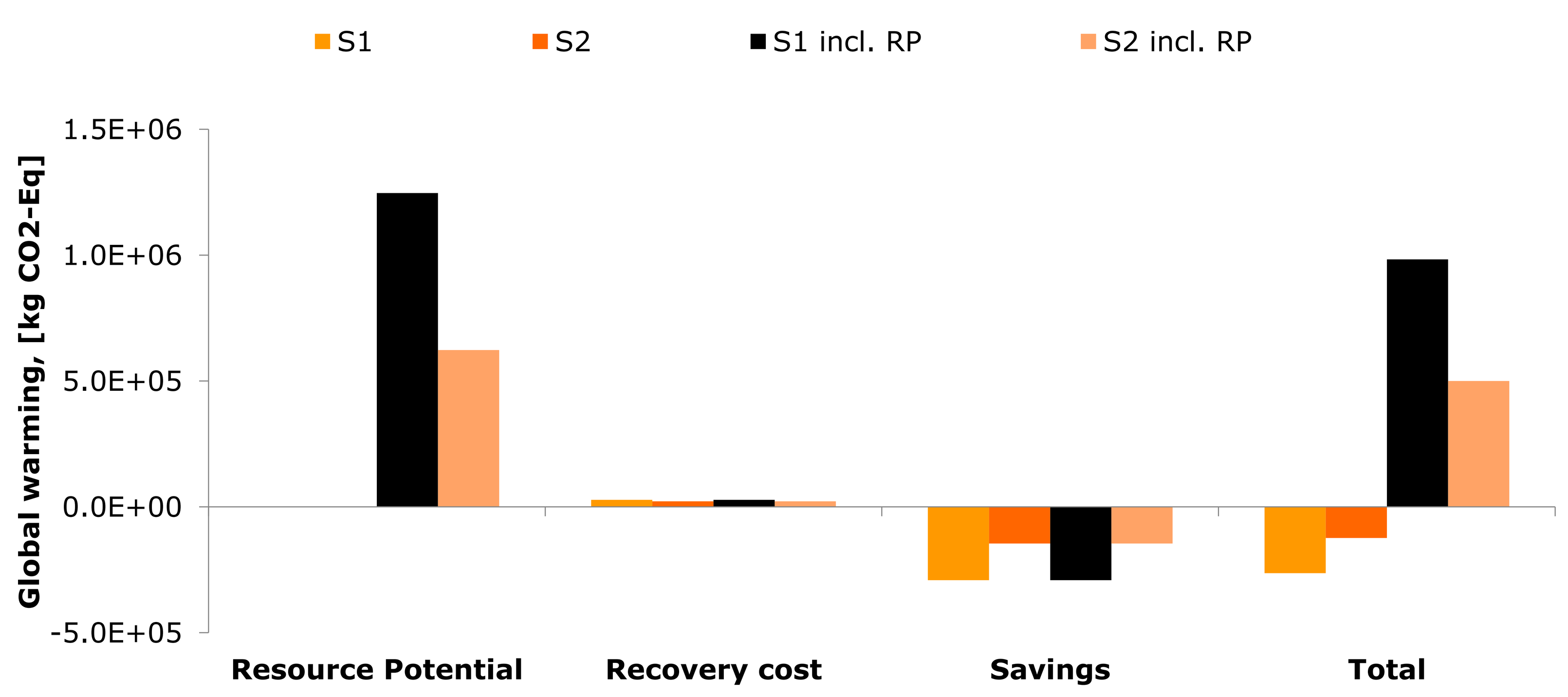

Figure 3: Characterized results of the two systems (S1 & S2) with and without including the Resource Potential (RP).

Comparison of the systems **without inclusion of the Resource Potential** in Figure 3

- S1 is perceived better due to a larger numerical saving
- This does not take into account the difference in input flow composition.

Comparison of the systems **including the Resource Potential** in Figure 3

- S2 performs better due to smaller numerical losses in the system
- the aggregated impacts (Total) therefore represents a lost potential for recovery.

Table: 1: Recovery performance indicators

	Recovery Effectiveness	Recovery Efficiency
S1 incl. RP	**23%**	**21%**
S2 incl. RP	**23%**	**20%**

The **recovery effectiveness** (Table 1) for each system is the same, since the ratio of inputs to recovered amounts are identical.

The **recovery efficiency** (Table 1) is 1% lower for "S2 incl. RP" due to higher recovery cost (Sorting and Treatment) wherefore S2 has a slightly lower performance than S1.

Conclusion

- The **proposed extension enables comparison between material recovery systems** by including the Resource Potential:
  - **Ordinary Gate-to-Grave LCA** in the case study shows **significant advantage for S1**
  - inclusion of **Resource Potential reveals identical rates of recovery** with S2 being only slightly less efficient than S1. In addition, the inclusion of Resource Potential highlights the higher **loss of potential for recovery in S1.**
- **Recovery Effectiveness & Efficiency** indicators provide information on the system performance **useful for compering and optimizing resource recovery** in WMS systems.
- The use of **Resource Potential** can **facilitate modeling** and comparison of upstream **waste prevention** activities.

- **Future studies** shall **explore:**
  - Recovery of **energetic resources** through e.g. incineration
  - **choice of where** in the product chain **to select level of raw material refinement** for e.g. composite materials.

References

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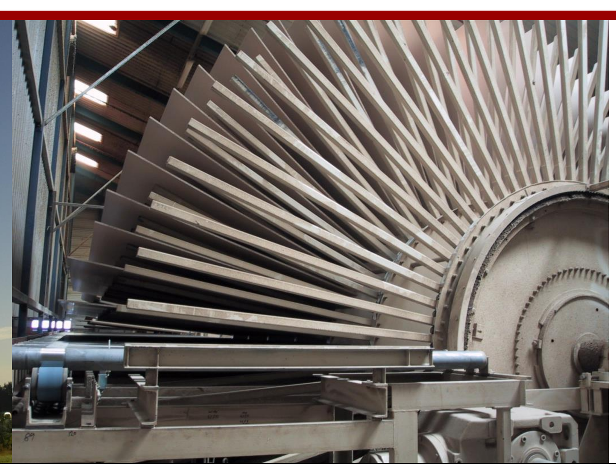
2. Allegrini E., Boldrin A., Astrup T.F. 2013. Life cycle assessment of metal recovery from municipal solid waste incineration bottom ash. Unpublished report for AFATEK A/S.







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